Soil Surface Roughness Measurement

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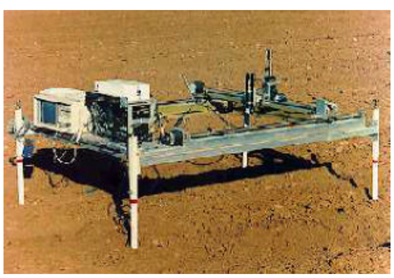
Soil surface roughness (microrelief) is important in wind erosion prediction because it influences trapping and emission of soil particles, abrasion of the soil surface by saltating grains, and the development of wind profiles (Hagen, 1988). Surface roughness effects on saltating soil particles and aggregates are especially important in the prediction of wind erosion (Potter et al., 1990).

We measure roughness using a laser roughness meter (Huang and Bradford, 1990) similar to the one pictured in Fig 1. The elevation of the laser beam on the soil surface is detected by a photodiode and stored in the laptop computer. The spacing of observations is controlled by software programs and very flexible. We typically measure surface elevations on a 5-mm grid spacing oner a one-meter square plot. This allows us to make 40, 401 observations per plot. The data are used to make mathematical descriptions of the soil surface.

The data can also be used directly to illustrate the roughness of a soil surface as shown in Fig 2. This figure shows a soil surface immediately after chisel tillage and after 83mm simulated rainfall on the same surface.

Fig 1.(Below) Laser roughness meter.



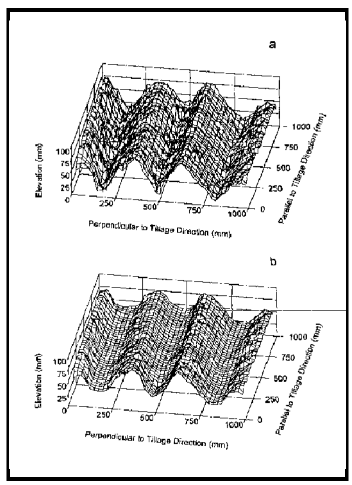
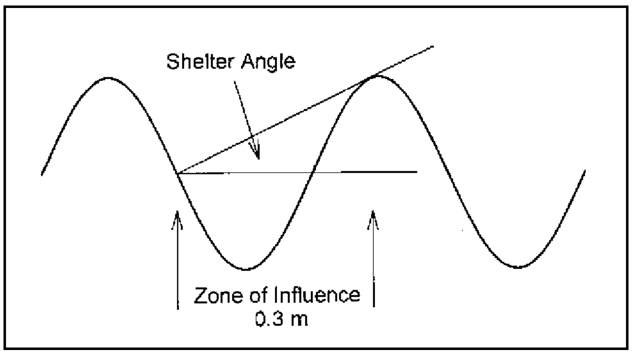


Fig 2. (Right) Representative soil surfaces immediately after tillage(A) and after 83 mm rainfall (B) at an intensity of 78mm h-1.

During wind erosion, saltating particles are lifted from the soil surface and transported downwind where they impact the soil surface. The point of impact is influenced by the particle jump length, angle of descent and surface roughness. Surface roughness can act to shelter part of the surface from the impact of saltating particles. Since, none of the previously proposed roughness parameters was capable of describing the sheltering effect of surface roughness directly, Potter et al. (1990) developed a new wind erosion roughness index called the cumulative shelter angle distribution (CSAD).

The index was based on a shelter angle concept. The shelter angle was defined as the minimum angle a particle must descend in order to strike a given point (Fig. 3).

Fig 3. Schematic cross-section of the soil surface showing the shelter angle and zone of influence used in cumulative shelter angle distribution calculations.

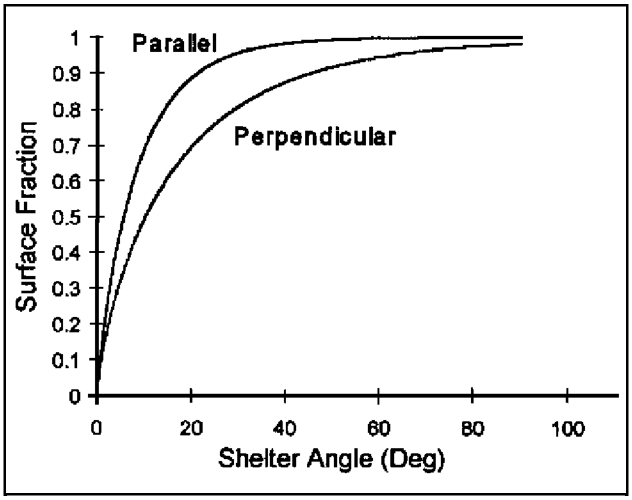


The descent angle for the given point was determined by calculating the maximum angle from horizontal between that point and adjacent points measured in a given direction within a specified zone of influence. For the zone of influence in this study, we tested all points within 0.3 m from the given point. For points with a negative shelter angle, indicating the test point had a higher elevation than other points within 0.3 m, the shelter angle was set to zero. Shelter angles are usually calculated for all plot observation points in directions parallel and perpendicular to the tillage direction using a modification of the Weibull distribution (Johnson and Kotz, 1970) as shown in Eq. 1.

$$SF = 1 - EXP[-\{SA/B\}^{C}] \qquad [1]$$

where SF is the surface fraction susceptible to impact abrasion by saltating grains, SA is the shelter angle, and the B and C parameters are estimated by least squares non-linear regression. We measured CSAD in directions parallel and perpendicular to tillage because these directions represent the extreme values of roughness measured on a field with oriented tillage marks. Cumulative shelter angle distributions measured perpendicular to tillage include roughness due to oriented tillage marks and random roughness caused by clods on the soil surface. CSAD measured parallel to tillage includes only random roughness (Potter and Zobeck, 1990). The CSAD for each direction is represented as the plot of cumulative fraction of observation points having a shelter angle less than a given shelter angle (surface fraction, SF) versus the given shelter angle (SA) as illustrated in Fig 4. Although, Potter et al. (1990) have shown CSAD is sensitive to tillage direction, tillage tool, and rainfall details of how these factors affect CSAD are not yet known.

Fig 4. Cumulative shelter angle distributions measured parallel and perpendicular to the tillage direction.



References

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